WYOMING GAME AND FISH DEPARTMENT

FISH DIVISION

ADMINISTRATIVE REPORT

TITLE: Red Creek Instream Flow Studies

PROJECT: FX-GR-3ES-511

AUTHOR: Paul D. Dey and Thomas C. Annear

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ABSTRACT

Studies conducted during 1997 determined instream flows necessary for maintaining Colorado River cutthroat trout (CRC) habitat and populations. Physical Habitat Simulation (PHABSIM), the Habitat Quality Index (HQI), and the Habitat Retention Method were used in determining instream flow water right recommendations of: October 1 - April 15 = 0.7 cfs, April 16 - June 30 = 4.8, and July 1 - September 30 = 0.9 cfs.

INTRODUCTION

Wyoming's instream flow law (W.S.41-3-1001) defines the Wyoming Game and Fish Department's (WGFD) role in identifying instream flow levels necessary to maintain important fisheries. According to the law, unappropriated flowing water "may be appropriated for instream flows to maintain or improve existing fisheries..." (W.S.41-3-1001(b)). WGFD instream flow recommendations must be for specific stream segments and seasons. These recommendations are incorporated into an instream flow water right application and, as provided by statute, may become an instream flow water right held by the state of Wyoming. This process ensures that adequate stream flow is protected when it is available in priority so that important fisheries will persist.

Since the law was passed in 1986 and through 1997, 76 instream flow water right applications have been filed, 7 approved by the state engineer, and 2 formally adjudicated. Initially, efforts were focused on WGFD class 1 and 2 waters, which are highly productive and provide popular recreational opportunities. More recently, efforts have shifted toward small headwater streams supporting native cutthroat trout.

Wyoming has historic ranges for Bonneville cutthroat trout (*Oncorhynchus clarki utah*, sometimes locally referred to as "Bear River" cutthroat trout), Colorado River cutthroat trout (*O.clarki pleuriticus*), and Yellowstone cutthroat trout (*O.clarki bouvieri*). A variant of Yellowstone cutthroat trout, the Snake River cutthroat trout, also occurs in the northwest portion of the state. Since

the early 1990s, instream flow studies have been done on many stream segments throughout the native range of Bonneville and Colorado River cutthroat trout. This report includes results and recommendations from studies on Red Creek, a Colorado River cutthroat trout stream.

The historic distribution and conservation status of Colorado River cutthroat trout is reviewed in Young (1996) and Nesler et al. (1999). In Wyoming, historic range includes streams tributary to the Green River: the Little Snake River drainage on the west side of the Sierra Madre mountains, Green River tributaries draining the east face of the Wyoming Range mountains, the Blacks Fork River and its tributaries arising in the Uinta mountains, and a few tributaries like Red Creek that flow directly into the Green River from the east. Prior to 1997, instream flow studies were conducted in the major drainages of the Wyoming Range and Sierra Madre mountains. During 1997, additional studies were performed in remaining streams such as Red Creek, an east-side tributary that flows into Utah before entering the Green River.

A conservation plan was developed by Wyoming, Colorado, and Utah state wildlife agencies, in coordination with the U.S. Fish and Wildlife Service, to guide conservation efforts in the tri-state area through three primary activities: protecting existing and restored ecosystems, restoring degraded ecosystems, and planning (Nesler et al. 1999). The process of acquiring and maintaining suitable instream flows is listed as a strategy for restoration. Obtaining instream flow water rights to be held by the state of Wyoming will provide assurance that available water will be reserved when it is available in priority for providing CRC habitat. Such efforts do not increase habitat from present levels or ensure that adequate habitat is available; instead, they act to avoid future water depletions up to the limits established by instream flow water rights. Instream flow water right acquisition is just one step in a comprehensive process of protecting and conserving native cutthroat trout habitat and populations.

Study objectives were to 1) investigate the relationship between discharge and physical habitat quantity and quality for Colorado River cutthroat trout in Red Creek and, 2) determine an instream flow regime that will help maintain the Red Creek Colorado River cutthroat trout fishery.

Study Area

Red Creek is located in southwest Wyoming in Sweetwater County, south of Rock Springs. It flows southwest into Utah and the Green River downstream of Flaming Gorge Reservoir (Figure 1). Land ownership in the Red Creek basin in Wyoming is primarily Bureau of Land Management (BLM) but most parcels abutting the proposed instream flow segment are State administered with a privately owned parcel near the downstream end of the segment (Red Creek Ranch, Figure 2). The upper boundary of the proposed instream flow segment is at about elevation 8,540 feet and is the boundary between section 34 Range 103W, Township 13N and section 3 of Range 103W, Township 12N. This point marks a location where the creek is fully formed from its primary springs. The downstream boundary for the proposed instream flow segment is the confluence with Little Red Creek. This marks the lowest point on Red Creek for which CRC are known to occur.
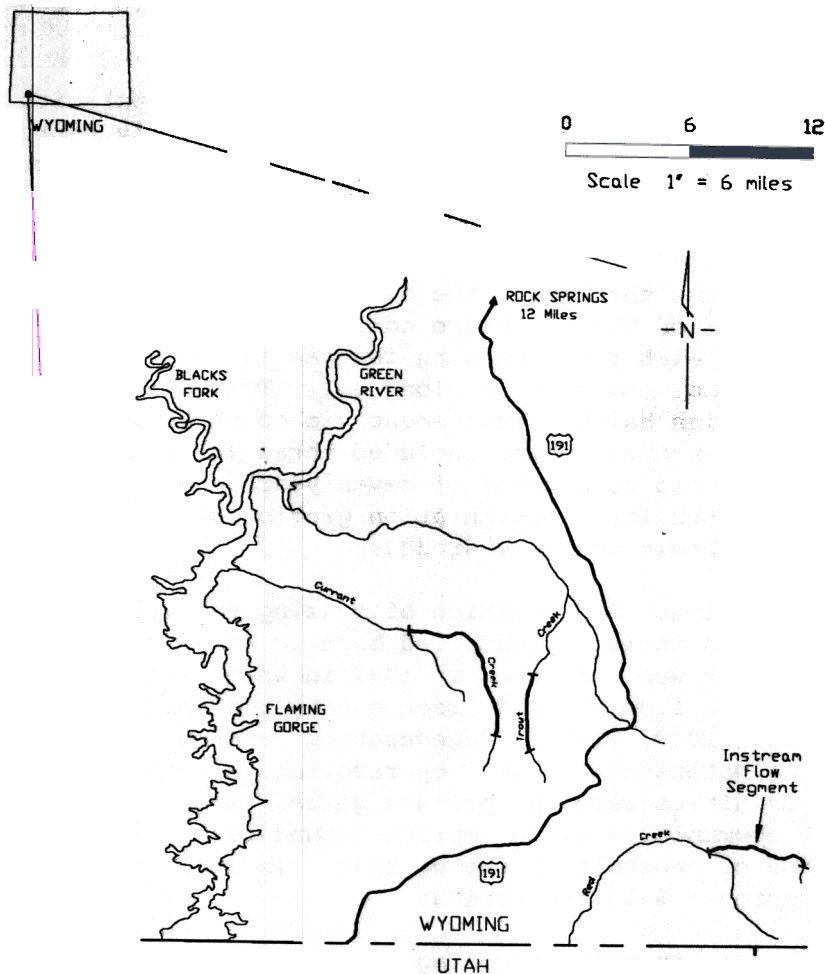

Figure 1   Red Creek instream flow segment and surrounding area

Red Creek earns its name from the red hue imparted by suspended sediments derived from the erosive red-colored aridisol soils common to this region of Wyoming and Utah. The stream originates in headwater springs at about 9,000 feet

elevation and flows north for about 1 mile then generally west for nearly 5 miles before the confluence with Little Red Creek at elevation 6910 feet. About 1 to 1.5 stream miles near the upper end of the proposed segment occur in a steep-walled canyon. The stream is in a region of highly dissected and steep fluvial slopes (Valley Type VII under *Rosgen and Silvey 1998*).

Watershed climate is semi-arid with 10-14 inches of annual precipitation in the headwaters and lesser amounts at lower elevations. Snowmelt run-off is typically in May while springs sustain baseflow the rest of the year.

Upland vegetation is approximately 80% sagebrush-grassland, 15% juniper, and 5% mountain shrub communities. Representative shrubs include mountain mahogany (*Cercocarpus montanus*), snowberry (*Symphoricarpos albus*), antelope bitterbrush (*Purshia tridentata*), rabbitbrush (*Chrysothamnus* spp.), sagebrush (*Artemesia* spp.), and saltbush (*Atriplex* spp.)

Riparian woody species are scattered and include willow (*Salix* spp), water birch (*Betula occidentalis*), currant (*Ribes* spp.), narrowleaf cottonwood (*Populus angustifolia*), aspen (*Tremuloides* spp.) and a very few dogwood (*Cornus stolonifera*).

Headwaters are dominated by subalpine fir (*Abies lasiocarpa*) with some lodgepole pine (*Pinus contorta*) and scattered aspen. This likely represents a climax community resulting from fire suppression during most of this century. An earlier successional stage of aspen-dominated vegetation likely prevailed in the past (Kevin Spence, WGFD, pers. comm.).

Red Creek Ranch operates throughout the basin and has been the historical lessee for cattle operations on BLM and State administered lands. The ranch came under new ownership in 1993 with corresponding changes in operation. Past operation involved traditional cow/calf yearlong use. The new owner's priorities include wildlife and fisheries habitat management via cooperative efforts with WGFD and the BLM. Original prescriptions included three years of rest from grazing; this has been extended to a total of seven years. A yearling cattle operation involving high intensity short duration grazing with rotations around the watershed is likely to begin in the year 2000.

In addition to curtailment and revision of grazing activities, other watershed management actions include prescribed burning and encouraging beaver colonization. A spring burn was conducted in 1997 in which approximately 1,500 acres was burned in a mosaic from the Red Creek county road crossing upstream to the middle of section 32 (R104W, T13N). Regenerating decadent riparian woody vegetation and enhancing watershed function by removing encroaching juniper in sagebrush/grassland communities were the primary goals. Mosaic burns encourage diverse mountain shrub communities which improve ground cover and result in better absorption and retention of snowmelt in the uplands. In addition, the increased vegetation diversity improves wildlife habitat.

Beaver re-colonization is being encouraged through re-introduction and supplementation with large woody materials to support solid dam construction. Evidence indicates strong beaver presence historically but no presence in the latter half of the century. This is coincident with a change in headwater vegetation communities from aspen-dominated before fire suppression to the subalpine fir (*Abies lasiocarpa*) dominated system of today. A goal of beaver re-introduction is an elevated water table thereby encouraging the establishment of

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additional woody species. Additional benefits include stabilized banks, reduced sediment sources from banks, and deep pools for overwintering trout.

The stream channel is incised throughout much of the segment and laterally constrained by its banks. Stream type under Rosgen and Silvey (1998) was characterized as G4, reflecting the following conditions: instability due to high sediment supply from both upslope and channel derived sources, moderate gradient, low width to depth ratio, and gravel dominated channel with mixtures of sand and some cobble. As a result of watershed improvement activities, 2-4 foot high willows are re-establishing along stream banks but increasing numbers of wildlife (moose and elk) are suppressing full expression.

RED CREEK INSTREAM FLOW SEGMENT NO. 1
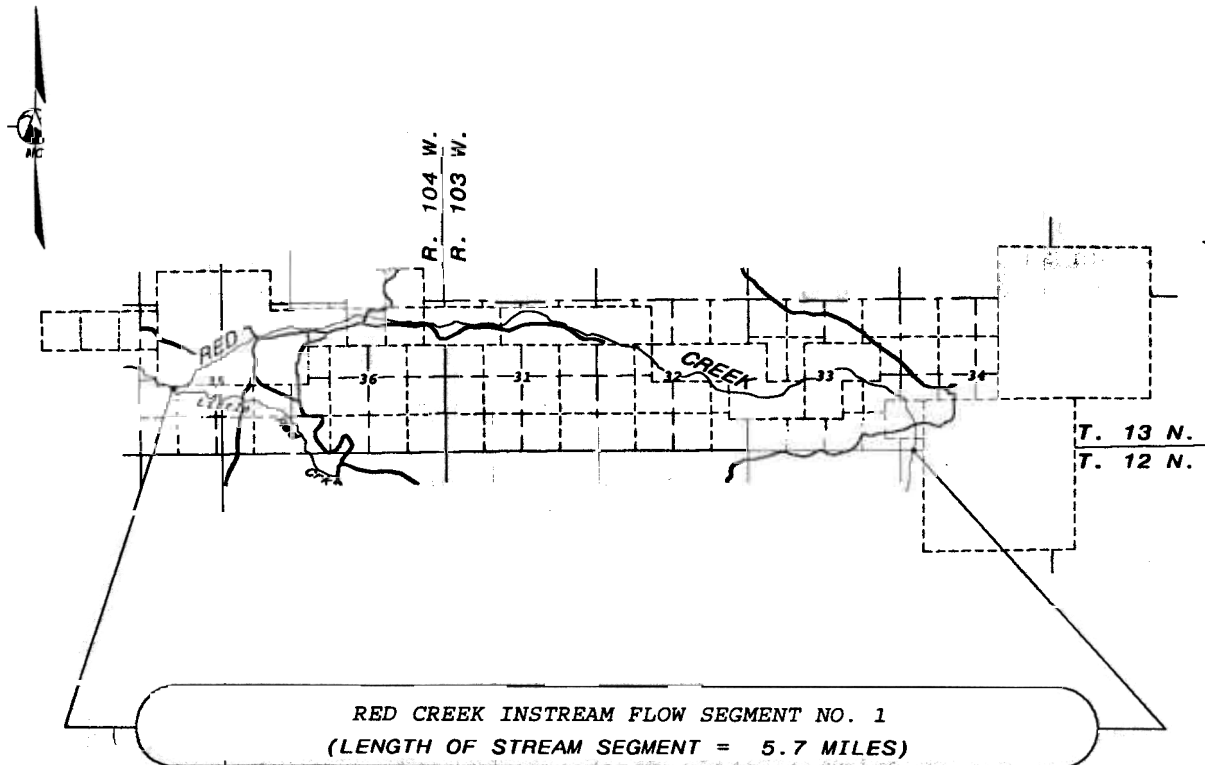(LENGTH OF STREAM SEGMENT = 5.7 MILES)

Figure 2   Detailed schematic of the Red Creek instream flow segment

Fisheries

Red Creek is in historic CRC range and currently sustains a healthy population. Earliest Red Creek records show brook trout were stocked in 1900 and stocking continued through the mid 1970s. Population estimates conducted in 1979 and 1982 indicate a brook trout dominated fishery. Brook trout stocking was replaced with Colorado River cutthroat trout in 1979 and 1982 and sampling in 1985 and 1987 yielded only cutthroat trout. The apparent elimination of brook trout occurred when supplemental stocking ceased. Brook trout likely could not recruit due to inadequate stream flow for spawning during October and November (WGFD Annual Progress Report on the 1987 Work Schedule, page 246).

.Spawning and young-of-year trout observations suggest that headwater canyon reaches (upstream of and including part of section 32) are an important spawning area. An abundance of fine gravel and relatively fewer fine sediments occur in these areas along with several springs providing stream flow recharge. During

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fall months, flow from these springs abates and provides little habitat for spawning brook trout. Spring spawning cutthroat, however, take advantage of higher streamflows and thus appear to have a competitive advantage.

Population data were collected in 1987, 1988, and 1989 from two stations located at R103W, T13N, S31, NW1/4 (lower, near instream flow study site) and R103W, T13N, S32, NW1/4 (upper). Over the three years assessed, lower site numbers declined from 287 to 19 trout/mile (54 to 2 lbs/acre) and upper site numbers declined from 265 to 135 trout/mile (128 to 11 lbs/acre). These declines were attributed to angling pressure during 1988 and high water temperatures with limited habitat exacerbated by drought and a history of excessive livestock grazing (WGFD Annual Progress Report on the 1989 Work Schedule, page 286). Due to poor habitat and low trout numbers, population estimates were stopped to reduce stresses to this already fragile population. In addition, the stream was closed to angling in 1990 and will be considered for re-opening after populations re-bound.

Following the watershed improvement projects started in 1993, trout were observed in Red Creek in 1997 near its confluence with Little Red Creek, in Little Red Creek, and in Lizzie Spring Creek (Kevin Spence, personal communication). On July 22, 1997 an additional 10 trout were observed from the bank near the instream flow study site during a search of about 2,000 feet of stream. An August 25, 1997 population estimate in the vicinity of the previous lower sampling station yielded an estimate of 74 trout/mile (46.3 lbs/acre). This indicates population improvement from 1989 levels but plenty of room for additional population expansion to attain 1987 population density.

In a western Oregon stream studied for 11 years, density of age 0 cutthroat trout (fry, <2 inches) varied from 8 to 38 per 100 m^2 and density of age 1 cutthroat trout (juveniles, 4-4.5 inches) ranged from 16 to 34 per 100 m^2 (House 1995). In this example, population fluctuations occurred despite the fact that habitat conditions were not degraded and appeared to be relatively stable. The author suggested that small changes in peak winter flows between years would have accounted for shifts in overwinter survival between age-classes.

Similar population fluctuations occur in Sand Creek, a Crook County, Wyoming stream that experiences relatively little discharge variation (Mueller 1987). Sand Creek brown trout population density ranged from 646 trout/mile to 4,060 trout/mile in a three-year period. Biomass estimates for the same period ranged between 48 and 142 pounds per acre.

These two examples illustrate that trout populations, particularly in small mountain streams, are expected to fluctuate. In Red Creek, steps are being taken to increase the minimum and maximum population potential by improving the watershed and channel. This will decrease the chances of CRC extinction during a low point in their population cycle. Under this framework, long-term trout population maintenance depends on periodic strong year classes produced in good flow years. Without benefit of periodic favorable flows, populations might decline or disappear. The WGFD instream flow strategy recognizes the inherent variability of trout populations and thus defines the "existing fishery" as a dynamic feature. Instream flow recommendations are based on a goal of maintaining habitat conditions that provide the opportunity for trout numbers to fluctuate within existing natural levels.

A representative study site was located at Township 13N, Range 103W, Section 31, NW1/4 on June 4, 1997(Figure 1). The site contained trout cover associated mostly with lateral scour pools and grassy banks. Eight transects were distributed among pool, deep run, run and riffle habitat types (Appendix 1). The relative abundance of these habitat types was estimated by measuring lengths of the identified units over a total channel length of 1,025 feet. Relative abundance's (31% riffle, 42% run, 16% deep run, and 11% pool) were used to weight modeling results from individual transects. Data for calibrating simulations were collected between May 22 and August 25, 1997 (Table 1).

Determining critical trout life stages (fry, juvenile, adult, etc.) for a particular time period is.necessary for developing flow recommendations. Critical life stages are those most sensitive to environmental stresses. Annual population integrity is sustained by providing adequate flow for critical life stages. In many cases, trout populations are constrained by spawning and young (fry and juvenile) life stage habitat "bottlenecks" (Nehring and Anderson 1993). The Fish Division's general approach includes ensuring that adequate flows are provided to

Table 1   Data collection dates for Red Creek instream flow data and discharge

Date	Discharge (cfs)
Instream flow data	
May 22, 1997	12.5
June 4, 1997	5.4
July 22, 1997	1.1
August 25, 1997	0.7
Flow data only	
May 5, 1998	8.0
July 12, 1994	3.2
October 7, 1998	1.2

maintain spawning habitat in the spring was well as juvenile and adult habitat throughout the year (Table 2).

Table 2. Colorado River cutthroat trout life stages and months considered in Red Creek instream flow recommendations. Numbers indicate method used to determine flow requirements.

Life Stage	J a n	F e b	M a r	Apr 1 to Apr 15	Apr 16 to Apr 30	M a y	J u n	J u l	A u g	S e p	O c t	N o v	D e c
Adult								1	1	1			
Spawning					2	2	2						
All	3	3	3	3	3	3	3	3	3	3	3	3	3

= Habitat Quality Index; 2 = PHABSIM; 3 = Habitat Retention

Habitat Retention Method

A Habitat Retention method (Nehring 1979; Annear and Conder 1984) was used to identify a maintenance flow by analyzing data from hydraulic control riffle transects. A maintenance flow is defined as the continuous flow required to maintain specific hydraulic criteria in stream riffles. Maintaining criteria in riffles at all times of year when flows are available in priority ensures that habitat is also maintained in other habitat types such as runs or pools (Nehring 1979). In addition, maintenance of identified flow levels may facilitate passage between habitat types for all trout life stages and maintain adequate benthic invertebrate survival.

A maintenance flow is realized at the discharge for which any two of the three criteria in Table 3 are met for all riffle transects in a study area. The instream flow recommendations from the Habitat Retention method are applicable year round except when higher instream flows are required to meet other fishery management purposes (Table 2).

Table 3. Hydraulic criteria for determining maintenance flow with the Habitat Retention method.

Category	Criteria
Mean Depth (ft)	Top Width[a] X 0.01
Mean Velocity (ft/s)	1.00
Percent Wetted Perimeter[b]	50

a - At average daily flow or mean depth + 0.20, whichever is greater
b - Percent of bank full wetted perimeter

Simulation tools and calibration techniques used for hydraulic simulation in PHABSIM (Physical Habitat Simulation) are also used with this technique. The PHABSIM method uses empirical relationships between physical variables (depth, velocity, and substrate) and suitability for fish to derive weighted usable area (WUA; suitable ft^2 per 1,000 ft of stream length) at various flows. The habitat retention method involves analysis of hydraulic characteristics at control riffles. The AVPERM model within the PHABSIM methodology is used to simulate cross section depth, wetted perimeter and velocity for a range of flows. The flow that maintains 2 out of 3 criteria for all three transects is then identified.

Habitat Quality Index

The Habitat Quality Index (HQI; Binns and Eiserman 1979; Binns 1982) was used to determine trout habitat levels over a range of late summer flow conditions. Most of the annual trout production in mountain streams occurs during the late summer, following peak runoff, when longer days and warmer water temperatures stimulate growth at all trophic levels. The HQI was developed by the WGFD to measure trout production in terms of habitat. It has been reliably used in Wyoming for habitat gain or loss assessment associated with instream flow regime changes. The HQI model includes nine attributes addressing biological, chemical, and physical aspects of trout habitat. Results are expressed in trout Habitat Units (HUs), where one HU is defined as the amount of habitat quality that will support about 1 pound of trout. HQI results were used to identify the flow

needed to maintain existing levels of-Colorado River cutthroat trout production between July 1 and September 30 (Table 2).

In the HQI analysis, habitat attributes measured at various flow events are assumed to be typical of late summer flow conditions. For example, stream widths measured in June under high flow conditions are considered a fair estimate of the stream width that would occur if the same flow level occurred in the month of September. Under this assumption, HU estimates are extrapolated through a range of potential late summer flows (Conder and Annear 1987). Red Creek habitat attributes were measured on the same dates PHABSIM data were collected (Table 1). Some attributes were mathematically derived to establish the relationship between discharge and trout habitat at discharges other than those measured.

Average daily flow (ADF; 4.7 cfs) and peak flow (65 cfs) estimates for determining critical period stream flow and annual stream flow variation are based on elevation and basin area (Lowham 1988). A Ryan temperature recorder monitored water temperature at 4-hour intervals between June 5 and August 25, 1997.

Physical Habitat Simulation

Physical Habitat Simulation (PHABSIM) methodology was used to quantify physical habitat (depth and velocity) availability for life stages over a range of discharges. The methodology was developed by the Instream Flow Service Group of the U.S. Fish and Wildlife Service (Bovee and Milhous 1978) and is widely used for assessing instream flow relationships between fish and physical habitat (Reiser et al. 1989).

The PHABSIM method uses empirical relationships between physical variables (depth, velocity, and substrate) and suitability for fish to derive weighted usable area (WUA; suitable ft^2 per 1,000 ft of stream length) at various flows. Depth, velocity, and substrate were measured along transects (*sensu* Bovee and Milhous 1978) on the dates in Table 1. Hydraulic calibration techniques and modeling options in Milhous et al. (1984) and Milhous et al. (1989) were employed to incrementally estimate physical habitat between 0.3 and 10.5 cfs.

Usable spawning area was modeled individually for three riffle transects. Physical habitat for other life stages was modeled in each of three short stream reaches and combined to depict the general relationship between flow and physical habitat. The spawning simulations were used in developing instream flow recommendations while the remaining simulations were used to validate the recommendations from the Habitat Retention and Habitat Quality Index models and provide incremental analyses of changes in physical habitat with flow.

Habitat suitability curves describing depth, velocity and substrate suitability for trout life stages are an important component of the PHAMSIM modeling process. The spawning suitability curves used for deriving instream flow recommendations are listed in Appendix 2. Curves for fry are from Bozek and Rahel (1992) while those for adults and juveniles were developed from bank observations of Colorado River cutthroat trout in Dirtyman Creek, tributary to Savery Creek.

Observations by WGFD biologists indicate spawning activity in Red Creek likely peaks in May during most years. Because spawning onset and duration varies between years due to differences in flow quantity and water temperature, spawning flow recommendations should extend from April 16 to June 30 (Table 2). Even if

spawning is completed before the end of this period, maintaining flows at a selected level throughout June will benefit trout egg incubation by preventing dewatering when the water right is in priority.

RESULTS AND DISCUSSION

Trout populations are naturally limited by extreme conditions during the winter months (October through March; Needham et al. 1945, Reimers 1957, Butler 1979, Kurtz 1980, Cunjak 1988, Cunjak 1996, Annear et al. *In Press*). Frazil ice (suspended ice crystals formed when water is chilled below 0°C) in high gradient stream reaches can be both a direct mortality source through gill abrasion and subsequent suffocation or an indirect mortality source when resultant anchor ice limits habitat, causes localized de-watering, and exerts excessive metabolic demands on fish forced to seek ice-free habitats (Brown et. al 1994). Pools downstream from high gradient frazil ice-forming areas can accumulate anchor ice when woody debris or surface ice provides anchor points for frazil crystals (Brown et. al 1994, Cunjak and Caissie 1994). Such accumulations may result in mortalities if low winter flows or ice dams block emigration.

Super-cooled water (<0° C) can also physiologically stress fish. As temperatures decrease below 4° C, fish gradually lose ion exchange abilities. At water temperatures near 0° C, fish have limited ability to assimilate oxygen or rid cells of carbon dioxide and other waste products. If fish are forced to be active near 0°C, such as to avoid frazil ice, direct mortalities can occur. The extent of impacts depends on the magnitude, frequency and duration of frazil events and the availability of escape habitats (Jakober et al. 1998). Juvenile and fry life stages tend to be impacted more than larger fish because younger fish inhabit shallower habitats and stream margins where frazil ice accumulates. Larger fish that inhabit deep pools may endure frazil events if they are not displaced.

Refuge from frazil ice occurs in groundwater influx areas, ice covered pools not close to frazil ice sources, and where heavy snow cover and stream bridging reduces frazil formation (Brown et al. 1994). Lower gradient streams and narrow streams are more likely to have insulating surface ice cover or at higher elevations, heavy snow cover and bridging. Red Creek's high elevation, relatively narrow width and moderate slope suggest that snow bridging occurs in the headwaters. Frazil ice formation may be a concern low in the instream flow segment mainly in early winter before sufficient insulating snow is present or in late winter when snow melt becomes superchilled by flowing over snow and ice before entering the stream. Therefore, natural winter flow levels up to the identified 0.7 cfs should be maintained to maximize access to and availability of frazil-ice-free refugia. Any artificial reduction of natural winter stream flows could increase trout mortality, reduce the number of fish the stream could support, and degrade the existing fishery.

Habitat Retention Analysis

Maintenance of naturally occurring flows up to 0.7 cfs is necessary at all times of the year (Table 4). The defining criteria in the analysis were wetted perimeter and depth. At flows lower than 0.7 cfs, average depth becomes limiting and riffles rapidly begin to dry up.

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Table 4. Simulated hydraulic criteria for two Red Creek riffles.
Average daily flow = 4.7 cfs. Bank full discharge = 31 cfs.

	Mean Depth (ft)	Mean Velocity (ft/s)	Wetted Perimeter (ft)	Discharge (cfs)
Riffle 2	0.72	5.79	8.1	31
	0.57	3.30	5.8	10
	0.44	2.28	5.3	5.0
	0.31	1.42	4.7	2.0
	0.25	1.02[a]	4.1	1.0
	0.24	0.97	4.1	0.9
	0.23	0.91	4.0	0.8
	0.22	0.85	4.0[a]	0.7[b]
	0.20[a]	0.79	3.9	0.6
	0.19	0.72	3.8	0.5
Riffle 3	0.74	5.98	7.6	31
	0.54	3.42	5.8	10
	0.43	2.41	5.2	5.0
	0.32	1.52	4.4	2.0
	0.24	1.07	4.0	1.0
	0.23	1.02[a]	4.0	0.9
	0.22	0.96	3.9	0.8
	0.21	0.90	3.8	0.7
	0.20[a]	0.84	3.8[a]	0.6[b]
	0.18	0.77	3.7	0.5

a - Hydraulic criteria met
b - Discharge at which 2 of 3 hydraulic criteria are met

The 0.7 cfs identified by the Habitat Retention Method may not always be present during the winter. Because the existing fishery is adapted to natural flow patterns, occasional shortfalls during the winter do not imply any degree of infeasibility or a need for additional storage. Instead, they illustrate the necessity of maintaining all natural winter stream flows, up to 0.7 cfs, to maintain existing trout survival rates. Furthermore, results from the HQI and PHABSIM methods below indicate that higher flows are needed during April through September to support spawning and adult life stages.

Habitat Unit Analysis

Article 10, Section d of the Instream Flow Act states that waters used for providing instream flows "shall be the minimum flow necessary to maintain or improve existing fisheries". One way to define "existing fishery" is by the number of habitat units that occur under normal July through September flow conditions. Since there is no stream flow gage on Red Creek, an estimate for discharge over the July through September period can be derived from the two flows measured in 1997 (Table 1). A reasonable estimate of late summer flow in Red Creek is thus about 0.9 cfs (half-way between the measured values of 1.1 and 0.7 cfs). This level of flow provides about 45 habitat units (Figure 3). To maintain 45 trout habitat units, the simulation shows that flows of 0.9 cfs to 1.2 cfs are needed. For the purpose of maintaining existing fishery values, the term "minimum" means the lowest amount of flow that will provide the identified fishery

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benefits, whenever it is naturally available. Therefore, the minimum flow to maintain existing trout production during late summer is 0.9 cfs.
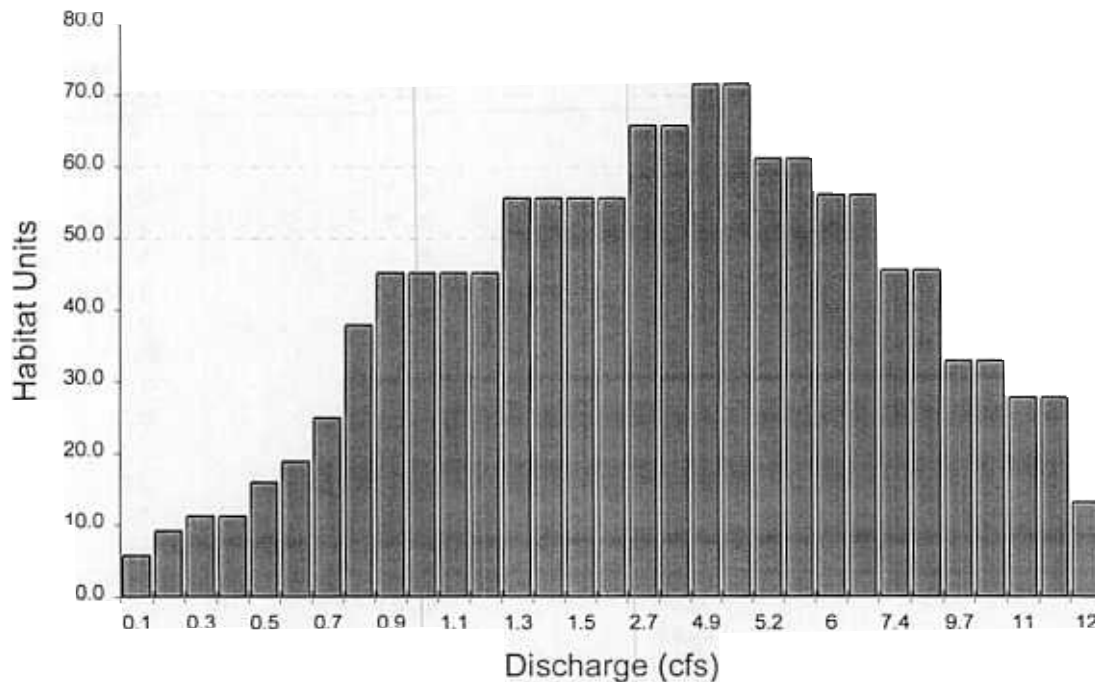

Figure 3   Trout habitat units at several late summer Red Creek flow
            levels.   X-axis discharges are not to scale.

Based on this analysis, an instream flow of 0.9 cfs between July 1 and September 30 would maintain existing trout habitat quality. This flow represents the lowest stream flow that will accomplish this objective if all other habitat attributes remain unchanged. The existing fishery is naturally dynamic as a function of stream flow availability. In years when stream flow is naturally less than 0.9 cfs in late summer the fishery declines. Likewise, in years when late summer flow is 0.9 cfs or more, it expands. As noted above, maintaining this existing fishery simply means maintaining existing natural stream flows up to the recommended amount in order to maintain the existing natural habitat and fish population fluctuations.

PHABSIM Analyses

Spawning was identified as a critical life stage. The amount of physical area suitable for spawning differed among transects as a function of flow (Figure 4). For example, transect 1 showed a peak at 4.8 cfs whereas transects 4 and 6 had peaks at low and high flow levels. Higher WUA on transects 4 and 6 at low flow do not reflect quality spawning area but is instead from the sum of several cells with low spawning suitability. The peaks at higher flow levels reflect higher quality spawning habitat and are more indicative of typical flow levels during the spawning season. Therefore, a flow of 4.8 cfs is the lowest flow leve that will maintain adequate levels of spawning habitat. The instream flow recommendation to maintain spawning habitat for the period from April 16 to June 30 is 4.8 cfs.
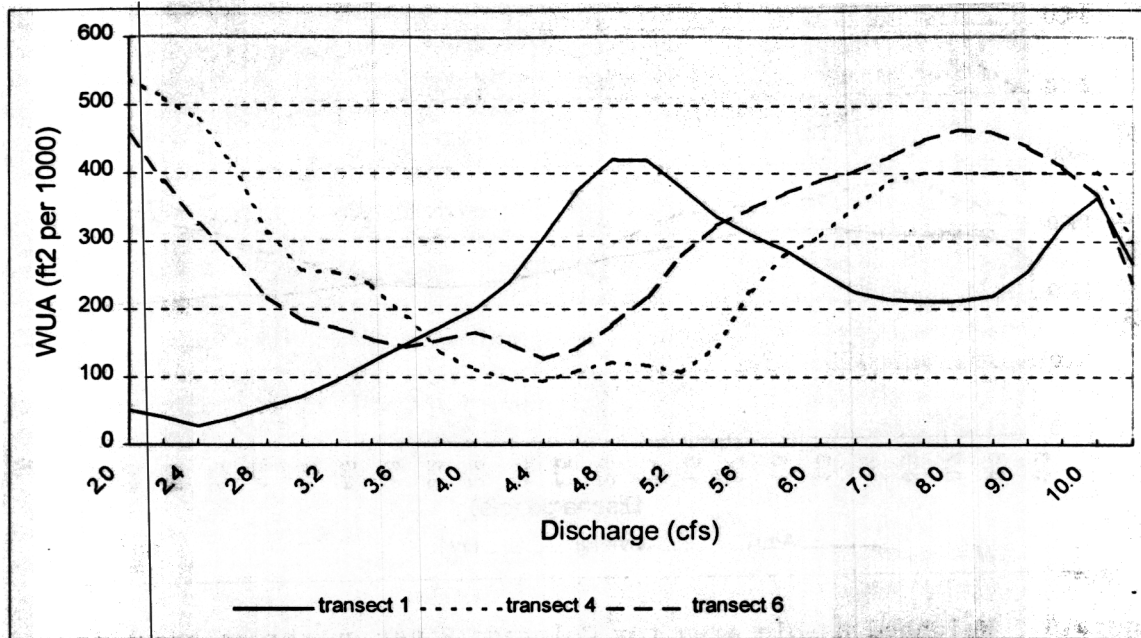
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Figure 4. Relationship between streamflow and spawning habitat for
three Red Creek riffles.

Physical habitat levels for adults, juveniles and fry do not change
drastically as a function of flow in Red Creek (Figure 5). All life stages have
fairly high levels of physical habitat at lower flow levels. The recommended
winter flow of 0.7 cfs derived from the Habitat Retention method would maintain
relatively high weighted useable area. Furthermore, the late-summer
recommendation of 0.9 cfs (HQI) maintains relatively high levels of physical
habitat for fry, juveniles, and adults.

INSTREAM FLOW RECOMMENDATIONS

Based on the analyses and results outlined above, the instream flow
recommendations in Table 5 will maintain the existing Red Creek Colorado River
cutthroat trout fishery. These recommendations apply to an approximately 6 mile
Red Creek segment extending downstream from the boundary between section 34 Range
103W, Township 13N and section 3 of Range 103W, Township 12N to the confluence
with Little Red Creek at Range 104W, Township 13N, Section 35. The land through
which the proposed segment passes is under BLM, State, and/or private
administration. Because data were collected from representative habitats and
simulated over a wide flow range, additional data collection under different flow
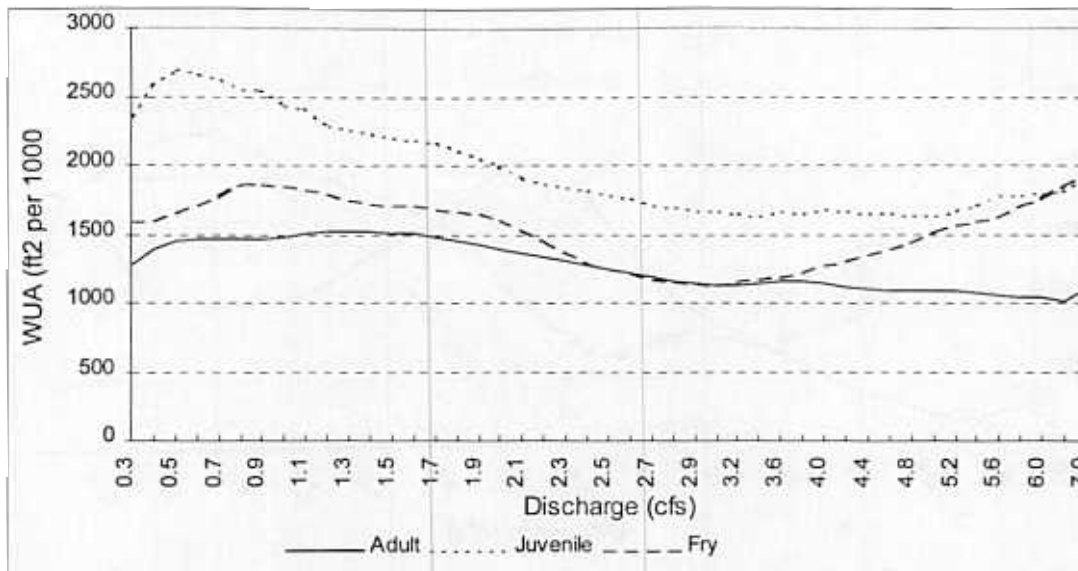conditions would not significantly change these recommendations.

Figure 5   Weighted usable area for Colorado River cutthroat trout in Red Creek over a range of discharges. X-axis discharges are not to scale.

Table 5   Instream flow recommendations to maintain the existing Red Creek trout fishery.

Time Period	Instream Flow Recommendation (cfs)
October 1 to April 14	0.7
April 15 to June 30	4.8
July 1 to September 30	0.9

This analysis does not consider periodic requirements for channel maintenance flows. Because this stream is unregulated, channel maintenance flow needs are adequately met by natural runoff patterns. If regulated in the future additional studies and recommendations are needed for establishing channel maintenance flow requirements.

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Appendix 1   Reach weighting used for PHABSIM analysis of fry, juvenile and adult physical habitat.

Transect	Reach Length (ft)	Percent	Habitat Type
1	2.65	9.8	Riffle/Spawn/Habitat Retention
2	3.91	14.4	Run
3	2.94	10.9	Pool
4	2.66	9.8	Riffle/Spawn/Habitat Retention
	4.94	18.2	Run
6	3.00	11.1	Riffle/Spawn/Habitat Retention
7	2.50	9.2	Run
8	4.50	16.6	Deep Run

Appendix 2   Spawning suitability index data used in PHABSIM analysis Index data are from Thurow and King, 1994.

Velocity	Weight	Depth	Weight	Substrate	Weight
0.00	0.00	0.00	0.00	0.00	0.00
0.59	0.00	0.32	0.00	4.00	0.00
0.69	0.10	0.34	0.10	4.10	0.10
0.94	0.20	0.37	0.20	4.20	0.20
1.10	0.50	0.45	0.50	4.30	0.50
1.12	1.00	0.52	1.00	4.40	1.00
1.72	1.00	0.82	1.00	5.60	1.00
1.82	0.50	0.97	0.50	5.70	0.50
2.06	0.20	1.27	0.20	5.80	0.20
2.26	0.10	1.58	0.10	5.90	0.10
2.31	0.00	1.75	0.00	6.00	0.00